Plant Document Analysis

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End of Engineering Analysis Report

ENGINEERING SPECIFICATION ANALYSIS

Focus Area: Nozzle Load Analysis

Generated on November 20, 2025

Focus: Nozzle Load Analysis

Below I extract only the specifications, parameters and measurement data from the submitted document that are directly relevant to performing a nozzle load analysis (i.e., items that an industry-standard nozzle/load/attachment analysis would require or use). I do NOT infer or add data not present in the document.

Section 1: Accepted Specifications for Evaluation of Nozzle Load Analysis

• Codes / standards / software references (documented as to-be-used tools relevant to nozzle/load and piping stress analysis):

• Piping stress analysis software listed: Caesar, NOZZLEPRO, CAEPIPE (Attachment 5.2 software table).

• Piping design standard reference: ANSI B31.3 (stated for process piping), IBR where applicable.

• Pressure vessel mechanical design: ASME Section VIII Div.1 or Div.2 (for vessels/columns).

• Seismic design: IS 1893 (seismic analysis document EPCMD-1-ENGG-DBD-CS-002 referenced).

• Design pressure / margin rules relevant to determining internal pressure loads for equipment/nozzles:

• Table of margin to be added to maximum operating pressure (for deriving Design Pressure):

• Vacuum to 1.8 kg/cm2 g (25 psig) → Design Pressure typically 3.5 kg/cm2 g (50 psig).

• to 17.6 kg/cm2 g → Design Pressure = Max Operating Pressure + 1.8 kg/cm2 g (25 psig).

• to 35.2 kg/cm2 g → Design Pressure = Max Operating Pressure × 1.1.

• to 70.3 kg/cm2 g → Design Pressure = Max Operating Pressure + 3.5 kg/cm2 g (50 psig).

• Over 70.3 kg/cm2 g → Design Pressure = Max Operating Pressure × 1.05.

• Design temperature and MDMT rules relevant to thermal loads and material selection:

• Default design temperature where not specified: 28°C plus coincidental temperature at design pressure (OSBL guideline).

• For temperatures beyond 343°C, Design Temperature = 14°C plus coincidental temperature at design pressure.

• Minimum Design Metal Temperature (MDMT) is the most stringent of:

• Minimum ambient temperature less 5.6°C

• Minimum operating temperature less 5.6°C

• Minimum equipment temperature caused by depressuring to the flare backpressure (note: margin not applied to depressuring).

• Vacuum / steam-out design guidance (relevant for transient nozzle loads):

• Columns and vessels subjected to steam out to be designed for at least half vacuum (0.5 kg/cm2 a) (vacuum design note).

• Steam-out condition used as example: 0.5 kg/cm2 a at 150°C when specified on vessel/line data sheets.

• Nozzle / connection requirements that affect nozzle reinforcement and minimum nozzle size:

• "Connections on pressure vessels shall be flanged, unless welded construction is preferred for reasons of safety."

• "Separate 2" nozzle shall be provided as steam-out or utility connections."

• For spheres and bullets (pressure vessels) minimum nozzle size: 1 ½" (document states: "On pressure vessels, minimum nozzle size shall be 1 ½".")

• For heat exchangers:

• Multipurpose connections (50 NB) to be provided on all process nozzles.

• Vent/drain: 1½" vent if exchanger is not vented from process nozzle; drain valve of adequate size (3" minimum) with spectacle blind on cooling water supply downstream of isolation valve.

• All heat exchangers to be provided with ¾" utility connection on inlet and outlet nozzles for hydrotest purpose.

• Thermowells at inlet and outlet on both shell & tube side (cooling water service only on outlet).

• Vessel vent/drain nozzle sizing guidance (affects nozzle sizes and loads):

• Vent nozzle sizing for vessels:

• up to 6 m3 → 1½"

• above 6 m3 → 2"

• Drain nozzle sizing for vessels:

• up to 6 m3 → 1½"

• to 15 m3 → 2"

• above 15 m3 → 3"

• Heat exchanger mechanical design constraints that affect nozzle loads:

• Low pressure side of shell & tube heat exchanger (including upstream and downstream) shall be designed for at least 10/13 times the design pressure of the high pressure side (to eliminate tube-rupture relief).

• Tube-to-tube-sheet joints: for critical applications, joint shall be expanded into 2 grooves and seal welded.

• Piping / isolation items relevant to nozzle loads:

• Spectacle blinds and spade/spacer sizes and where to provide (affect isolation and end loads).

• Control valve block & bypass manifold rules (bypass valve sizing equivalent Cv to control valve).

• Materials / corrosion allowance (affect reinforcement and thickness calculations around nozzles):

• Corrosion allowance for static equipment:

• Carbon steel / low alloy (up to 2¼% Cr) → 3 mm

• Low alloy (above 2¼% Cr up to 9% Cr) → 1.5 mm

• Cladding minimum thickness 2 mm; cladding counted as CA (minimum 3 mm).

• Storage tanks: shell & bottom CA 1.5 mm; roof 1 mm.

• Process piping corrosion allowances: carbon steel non-corrosive/mildly-corrosive → 1.5 mm; moderately-corrosive → 3 mm; stainless corrosive → 1.5 mm.

• Units and conventions relevant to loads / units conversions:

• Force unit N and moment Nm (UOM section defines Force, Moment units).

• Pressure units used throughout: kg/cm2 g and kg/cm2 a (absolute/gauge) and mm Hg abs; temperatures in °C.

• Piping & vessel design codes to follow for mechanical details that impact nozzle reinforcement: ASME Section VIII, API for specific items (API pumps, API 617 compressors etc.) as referenced throughout.

Section 2: Measurements Provided in Document (explicit numeric values relevant to nozzle load analysis)

- Site / environmental loads and data:
- Site coordinates: Lat 22°22' N, Long 69°51' E.
- Wind (onshore): 50 m/s 3-second gust at 10 m elevation (50-year return).
- Offshore wind (operational): 15 m/s mean hourly at 10 m (5-year return).
- Offshore wind (extreme survival): 33 m/s mean hourly at 10 m (500-year return).
- Wind for flare heat radiation: 11.5 m/s (used for flare radiation calculations).
- Seismic standard: IS 1893 (site spectra reference).
- Temperatures (loads for thermal calculations / piping stiffness at temperature):
- Maximum recorded DBT: 48°C
- Minimum recorded DBT: 3°C
- Design Temperature (DBT) for Air Coolers: 41°C
- Electrical design temperature outdoors: 43°C; indoors: 40°C
- Design Surface Temperature (solar-exposed): 65°C
- Winterizing Temperature (heat tracing basis): 10°C
- Low ambient design temperature: 7.5°C
- Rain, humidity, pressure (affects thermal and condensation considerations):
- Maximum rainfall rate: 61 mm/h
- Max 24-hr rainfall: 522 mm/24 hrs
- Humidity max: 92.8% min: 27.0%
- Atmospheric pressure: Max 1.034 kg/cm2 a; Normal 1.024; Min 1.003 kg/cm2 a
- Wave / marine loads (for marine-connected equipment nozzles if applicable):
- Tide levels: Highest Astronomical Tide +6.15 m; Mean Sea Level +3.10 m; Lowest Astronomical Tide -0.30 m.
- Surge set-up 0.8 m, set-down 0.3 m.
- Significant wave heights per location and return period (e.g., Berth D operational Hs 1.3 m / extreme 2.4 m etc.) — see Attachment 1 tables.
- Current velocities (operational): e.g., 1.60 m/s at 129.41° +/-10°; extreme 1.85 m/s (table shown).
- Noise (not usually part of nozzle loads but included): equipment noise limit 85 dBA at 1 m from skid edge.

• Design life: 20 years (affects corrosion allowance, load cycles).

• Corrosion allowances (relevant to mechanical reinforcement thicknesses):

• Static equipment carbon steel CA: 3 mm; low alloy >2.25%Cr up to 9% Cr CA: 1.5 mm.

• Process piping carbon steel non/mildly corrosive: 1.5 mm; moderately corrosive: 3 mm; stainless corrosive: 1.5 mm.

• Storage tanks shell & bottom: 1.5 mm; roof 1 mm.

• Minimum cladding thickness 2 mm; cladding counted as CA minimum 3 mm.

• Vessel and nozzle sizing values:

• Minimum nozzle on pressure vessels: 1½" NB.

• Vessel vents/drains: vents up to 6 m3 = 1½"; above 6 m3 = 2". Drains up to 6 m3 = 1½"; 6.1–15 m3 = 2"; above 15 m3 = 3".

• Manway sizes: vessel dia 900–1500 mm → 20" NB; above 1500 mm → 24" NB. Minimum ID manhole 20".

• Heat exchanger nozzle and connection sizes:

• Multipurpose connections: 50 NB on all process nozzles.

• Hydrotest utility connection: ¾" on inlet and outlet of tube & shell side.

• Drain valve for back-flushing: minimum 3" with spectacle blind (cooling water supply downstream).

• Heat exchanger tube / mechanical dimensions that influence nozzle loads:

• Preferred tube length 6.0 m (alternates 15, 12, 9, 4.5, 3.0 m).

• Tube OD minima: where tube side fouling <0.0004 use 20 or 25 mm; where >0.0004 use min 25 mm.

• Tube thickness minima: Carbon steel tube 20 mm OD → 2 mm; 25 mm OD → 2.1 mm. Stainless steel 20 mm → 1.6 mm; 25 mm → 2.0 mm. Titanium 20 mm → 1.245 mm.

• Fouling factors (used for exchanger sizing and indirectly for nozzle sizing when geometry changes):

• Fresh CW 0.0003 hr·m2·°C/kcal

• Sea water 0.0006

• Steam 0.0001

• Condensate 0.0002

• Hydrocarbons typically not less than 0.0003

• Pump / piping NPSH and mechanical margins that may influence connected-piping nozzle loads:

• Shutoff head requirements for pumps: minimum 105% of rated point (single), 110% for parallel; preferably limited to 120% of head at rated point.

• NPSHr shall be lower than NPSHa by at least 1 m throughout operating range (unless datasheet dictates otherwise).

• Piping sizes to be avoided (affects connection selection):

• Pipe sizes 1¼", 2½", 3½", 5", and 9" shall not be used.

• Steam and condensate battery limits (explicit pressures and temperatures relevant for nozzle design):

• Steam battery limits (Attachment 3):

• HHP Steam: Min 101, Normal 106, Max 109 kg/cm2 g; Design 117 kg/cm2 g; Temperatures Min 490°C Normal 510°C Max 515°C Design 540°C.

• HP Steam: Min 40.1, Normal 42.2, Max 43.2 kg/cm2 g; Design 47.6 kg/cm2 g; Temp Normal 383°C; Design 426°C.

• MP Steam: Min 15, Normal 16, Max 17.2 kg/cm2 g; Design 21.1 kg/cm2 g; Temp Normal 232°C; Design 288°C.

• LP Steam: Min 3.5, Normal 4.1, Max 4.6 kg/cm2 g; Design 8.1 kg/cm2 g; Temp Normal 158°C; Design 260°C.

• Condensate battery limits:

• HP Condensate: Normal 42.2 kg/cm2 g; Temp Normal 254°C.

• MP Condensate: Normal 16 kg/cm2 g; Temp Normal 203°C.

• LP Condensate: Normal 4.1 kg/cm2 g; Temp Normal 152°C (temperatures are saturation temps at corresponding pressures).

• Boiler feed water battery limits (pressures and temperatures relevant for piping attachments):

• HHP BFW Normal 127.7 kg/cm2 g; Design 163.2 kg/cm2 g; Temp Normal 121°C; Design 150°C.

• HP BFW Normal 59.2 kg/cm2 g; Design 78 kg/cm2 g.

• MP BFW Normal 23.9 kg/cm2 g; Design 33.8 kg/cm2 g.

• LP BFW Normal 10.9 kg/cm2 g; Design 17.6 kg/cm2 g.

• Cooling water battery limits and temperatures (affect heat exchanger nozzle temps/pressures):

• Fresh cooling water supply pressure at source 5.1 kg/cm2 g and temperature 32°C (DTA/SEZ typical); unit BL supply pressure/return given in cooling tables (supply 32°C, return 45°C typical; max outlet exchanger temp 49°C; design heat-exchanger water-side temp 120°C shown in a table).

• Fuel gas battery limits (pressures and temperatures relevant for nozzle loads on fuel gas connections):

• Fuel Gas: Min 3.2 kg/cm2 g, Normal 3.9, Max 4.6; Design 6.5 kg/cm2 g; Temperatures Min 38°C Normal 38°C Max 94°C Design 120°C.

• PSA tail gas min pressure: 2 kg/cm2 g (note).

• Syn gas pressures to GTG and HRSGs: Syn Gas@GTG Normal 25 (unit not explicitly kg/cm2 g in that row but table heading uses kg/cm2 g), Syn Gas@HRSGs/aux Boilers Normal 6; temperatures also listed (20 to 100°C ranges).

• Plant air, instrument air, breathing air battery limits:

• Plant Air: Min 5, Normal 7.7, Max 8.5 kg/cm2 g; Design 10 kg/cm2 g; Temperature Normal 40°C; Design 65°C.

• Instrument Air: Min 6, Normal 7, Max 8 kg/cm2 g; Design 10; Temp normal 40°C.

• Breathing Air: Min 6, Normal 9.1 kg/cm2 g; Design 10 kg/cm2 g.

• Instrument Air dew point -40°C.

• Nitrogen specifications relevant to nozzle piping and purity-sensitive connections:

• Nitrogen purity: 99.99 vol% (min) stated; oxygen <5 ppm v/v (for high purity N2); ASU supply to EO/EG at 7.7 Barg with O2 <5 ppm.

• LLP/LP/MP nitrogen battery limit pressures: High pressure N2 Normal 13.7 kg/cm2 g (Min 13); LP N2 Normal 7 kg/cm2 g (Min 6.5).

• Fuel gas and natural gas compositions and LHV values in Attachment 2 (affect density and internal loads but only compositional data present):

• Example natural gas typical composition rows and LHV values given (e.g., Natural gas composition with C1 98.2 mole% LHV 11,844 Kcal/kg MW 16.4).

• Indicative syn gas compositions and LHV values (e.g., LHV 10,633 Kcal/kg, MW 15.2).

• Miscellaneous mechanical values affecting nozzle design:

• Pump motor sizing notes: motors for pumps <22 kW sized at least 125% of rated power; ≥22 kW motors sizing guidance (affects load transmitted to piping).

• Pump backflow prevention check-valve counts by pressure range (affects nozzle piping).

• Heat exchanger tube velocities min values (e.g., Cooling Water min 1.3 m/s; slurry oil 1.5 m/s to 2.3 m/s).

Section 3: Inputs and Additional Requirements from Client (explicit inputs and stated missing / to-be-firmed items)

• Inputs provided in the document that are relevant to nozzle-load work:

• Software recommendation for piping stress / nozzle loads: Caesar, NOZZLEPRO, CAEPIPE (document specifically lists NOZZLEPRO).

• Codes and standards precedence: Indian statutory rules, project requisitions, RIL requirements, then International Codes.

• Seismic design standard: IS 1893 (identified for seismic spectra).

• Typical battery-limit pressures and temperatures for many utilities and services are provided in Attachment 3 (steam, condensate, BFW, fuel gas, nitrogen, cooling water, instrument air, dematerialized water, potable water, fire water etc.).

• Vessel/nozzle sizing rules (minimum nozzle sizes, vent/drain sizes, multipurpose 50 NB, hydrotest ¾" conn, 3" minimum drain valve).

• Nozzle size exclusions for piping (1¼", 2½", 3½", 5", 9" shall not be used).

• Corrosion allowances and material guidance to be used in thickness calculations (see Section 9.6).

• Explicit items the document states will be provided later / must be firmed up (i.e., missing for complete nozzle load analysis and explicitly called out):

• "Typical battery limit pressures and temperatures are indicated in Attachment 3. These numbers will be firmed up as system design progresses." (multiple occurrences) — i.e., final, binding battery limits are not provided and must be supplied during detailed design.

• Licensor data and vendor datasheets to be followed for equipment details: document repeatedly states "Licensor process datasheet is to be followed" and that licensor/BEC/DEC will advise material selection and corrosion allowances. Therefore the document does not contain final nozzle coordinates, nozzle reinforcement details, and equipment/vendor allowed loads.

• For sea-water and desalination qualities and make-up sources: several entries say "To be confirmed" — therefore final temperatures/pressures/qualities at particular tie-in points are pending.

• Seismic spectra: reference to EPCMD-1-ENGG-DBD-CS-002; seismic design is required but the document does not include numerical site response spectra or Ss/S1 values — those are to be taken from the referenced seismic document.

• The document notes that many parameters (battery limits, exact pressures, samples of piping routings, support locations, nozzle coordinates, equipment weights & center-of-gravity, allowable nozzle loads from equipment vendors) will be "firmed up during facility design" or "to be provided by Licensor/OSBL designer/DEC" — these are explicitly identified as outstanding.

• Items explicitly called out as required by the project for further design (relevant to complete nozzle load analysis):

• "Actual velocities at the prospective locations of new berth areas shall be verified by float track measurements." (if nozzle loads include marine current forces on connected piping/structures).

• "The OSBL designer shall ensure battery limit parameters are satisfied" — indicates final BL data is an input to be provided.

• Piping stress analysis basis: "All critical circuits will be checked against actual piping configurations and against as purchased equipment." — implies the need for as-built/purchase equipment data.

• Instrument and control air isolation sizing note: "For isolation valve actuator sizing use 4.5 kg/cm2 g." (an explicit actuator-supply pressure guidance).

• Nozzle loads and reinforcement calculations must follow licensor/ASME/Project piping specifications (document instructs to follow licensor and piping spec EPCMD-1-ENGG-DBD-PP-001).

• No equipment-specific nozzle coordinates, orientations, or exact nozzle reinforcement dimensions.

• No equipment-specific weights, center-of-gravity, nor erection/lifting load data.

• No vendor-supplied allowable nozzle loads or allowable moments/forces for equipment.

• No piping run layouts, exact spring/anchor/support locations, or pipe flexibility model data.

• No site-specific seismic response spectrum numeric values (only code reference IS 1893).

• No detailed piping material stiffness or SIF (stress intensification factor) tables—these would come from piping spec or vendor.

• No final battery-limit confirmation (document repeatedly states battery limits will be firmed up).

• No explicit allowable nozzle load tables (ASME/WRC-derived allowable load values are not contained in this document).

• Map the specific Attachment 3 battery-limit pressures/temperatures onto a checklist of required input parameters for a nozzle load run (NOZZLEPRO/Caesar), indicating exactly which values are still missing.

• Produce a concise input-data checklist (equipment weights/CG, nozzle coordinates, reinforcement dimensions, flange ratings, connected piping geometry/supports, seismic spectra Ss/S1, operating/relief pressures and temperatures, thermal transients) you must collect from licensor/vendors to run a nozzle-load analysis with NOZZLEPRO or Caesar.

Which of those would you like me to prepare next?

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